SMITH (J. LAW.)

Memoir on Emery.

Smith on emery

alph. box.

MEMOIR ON EMERY.

EXTRACTED FROM THE AMERICAN JOURNAL OF SCIENCE AND ARTS, VOL. X, SECOND SERIES, 1850.

MEMOIR ON EMERY.

BY

J. LAWRENCE SMITH, M.D.

First part—*On the Geology and Mineralogy of Emery, from observations made in Asia Minor.*

Read before the Academy of Sciences of the French Institute, July 15th, 1850.

Of all the mineral substances employed in the arts, few have offered so little opportunity for geological examination as emery, and consequently our knowledge of it in this particular is very limited.

Aware of the importance of the study of this substance *in situ*, both in a scientific and practical point of view, I did not lose the opportunity afforded by my late position under the Turkish government to develop certain facts that came under my notice the latter part of the year 1846. Prior to that period, emery (which term is here used as in the arts to express that mixed granular corundum employed for abrasion) although known to exist in many places in greater or less abundance, was supplied to the arts almost entirely from the island of Naxos in the Grecian Archipelago; so true is this, that the proprietors of the mines in that island controlled completely the price of this mineral. The emery from Naxos frequently went under the name of Smyrna emery, from the fact of its coming to us from that port, where it is originally carried from the island for future exportation.

Prior to 1846, the existence of emery was not remarked in Asia Minor or any of the contiguous islands except that of Samos, which fact is alluded to in Tournefort's travels in the seventeenth century. In the latter part of 1846, I arrived in Smyrna, and was shown specimens which I recognized as emery that came from a place about twenty miles north of Smyrna; they had been first discovered through the agency of a knife grinder of the country, who had been in the habit of using it to charge his wheels with. The importance of this circumstance to the Turkish government as well as to the arts (emery being at that time sold at a most exhorbitant price) induced me to return to Smyrna in the early part of 1847, for the purpose of examining the supposed locality of this mineral. On this second visit other localities were made know to me that an English merchant by the name of Healy had succeeded in bringing to light.

The first locality towards which I directed my examination was that of *Gumuch-dagh*, a mountain about twelve miles east of the ruins of *Ephesus*. Before, however, arriving there, I discovered this mineral imbedded in a calcareous rock in a valley twenty miles south of Smyrna, called *Allahman-Bourgs;* the position not being very favorable for the study of the geology of this substance, my route was continued to the place originally fixed upon. Obtaining guides at the village of *Gumuch*, I commenced the examination of the mountain, which is composed of bluish marble resting on mica slate and gneiss. On the very summit of the mountain, the emery was found scattered about and projecting above the surface of the soil. After examining the extent of the formation and satisfying myself that it was there *in situ*, I returned to Constantinople, and made a report to the Ottoman government. Although I gave no notice to the scientific world of the result of my examination, the editor of the *Journal de Constantinople* inserted a small note in his journal in May, 1847, to the following effect—

"It is some time since M. Lawrence Smith, American Mineralogist, discovered at Magnesia near to Gumuch-Kuey an emery mine, of which he brought specimens to Constantinople. The government have sent to the place a commission composed of M. Smith and some of the officers of the imperial powder works, to examine thoroughly into the importance of this mine, and according to the report that will be made the government will decide on the steps to be taken with reference to it, &c."

This circumstance, unimportant in itself, has subsequently become of great value to secure to me the priority of the discovery and examination of emery *in situ* in Asia Minor;* and also to show that I have been instrumental in the development which has

* See Am. Jour. Sci., 2nd ser., vol. vii, 283.

been subsequently given to this emery in a commercial point of view. Since the first discovery other localities have been ascertained by me, all of which will be alluded to in this memoir.

Localities of Emery in Asia Minor and the neighboring islands.

Gumuch-dagh.—In going from Ephesus east to *Gouzel-Hissar* (the ancient *Tralles*) we pass by the ruins of the ancient city of Magnes on the Miandre and near to this latter is a beautiful valley, celebrated for its figs, in which is situated the village of *Gumuch* at the foot of a mountain bearing the same name. It was here that the emery formation was first examined. All the rocks of the surrounding country appear to belong to the old series; the limestone is entirely devoid of fossils and metamorphic in its character; it rests on the older schists of which mica schist appears the most abundant, and this again farther to the north was traced in contact with gneiss. The limestone is of a light blue passing into a coarse grained marble; and on the south side, the rock by its decay leaves in many places precipices of considerable elevation, that add much to the picturesque appearance of the region.

The emery is found in different places in the *Gumuch* mountain; the place, however, to which it is traced in greatest abundance, is on a part of the summit about three miles from the village of Gumuch, and some fifteen hundred or two thousand feet above the level of the valley; it overlooks the magnificent plain of the Miandre, whose curiously tortuous course is seen as if traced on a map. The emery lies scattered on the surface in the greatest profusion, in angular fragments of a dark color, and large masses of several tons weight are seen projecting above the surface; in penetrating the soil, the emery is found imbedded in it and a little farther down it is come to in the rock. In fact by breaking the marble that projects above the surface at this spot we are sure to find nodules of the mineral.

Sometimes the emery forms almost a solid mass several yards in length and breadth. One of these places, opened for the purpose of exploring, is about ten or twelve yards square and all the rock taken out is emery; the spaces between the blocks are filled with an earth highly charged with oxyd of iron. In some places the masses are consolidated by carbonate of lime of infiltration, which must not be confounded with the emery in its original gangue (the marble) in which it is found in nodules sometimes round and at other times fissured so as to represent angular fragments. In no place does it present anything like a vein, nor has it signs of stratification. The largest mass at this locality that I saw unbroken must weigh from thirty to forty tons.

Attached to this mineral, more especially in the fissures and on the surface, are several minerals that will be alluded to hereafter.

Kulah.—This locality of emery is the second in importance in Asia Minor, it is a town situated about a hundred and fifty miles from *Gumuch* and twenty miles from the ancient city of Philadelphia (one of the seven churches). It is near the river Hermes, and on that interesting volcanic district of Asia called *Catacecaumene* or the burnt country, resembling in many respects the volcanic region of Auvergne. The rocks forming the base of this region are of the older metamorphic series, covered to a greater or less depth by lava of different volcanic periods, which has flowed from the numerous craters that form the prominent feature of this region. The most common rocks in the mountain ranges about Kulah are white granular limestone, mica slate, hornblende schist, gneiss and granite; the last four are seen more conspicuously in the mountain two or three miles to the south, which have not been subjected to volcanic action; the limestone overlies these rocks.

Before arriving at the place where I examined the emery, (about two miles to the northeast of Kulah,) an outcropping of gneiss was seen and subjected to the closest scrutiny, without discovering the slightest trace of corundum; and I will here remark that although I have found several thin layers of mica schist engaged in the marble, in no instance was there any trace of corundum in it.

The marble in this region is very compact, of great hardness and I may also add of great purity. I cannot say whether this hardness is traceable to a greater depth than that to which it has felt the influence of the superimposed lava. Here again the emery was found on the surface, but not in such abundance as at *Gumuch-dagh*, and moreover the soil is not as deep as in the latter place. The emery as seen in the marble at Kulah is capable of being studied with the greatest satisfaction, particularly as two or three places in the rock have been quarried.

Adula.—Not far from this town which is about twelve or fifteen miles east of Kulah, I have also discovered emery, only, however, in very small quantity.

Manser.—About twenty-four miles north of Smyrna, emery is found in small quantity in the soil. In this as well as in the former place, white granular limestone is found.

Island of Nicaria, Grecian Archipelago.—I have also been able to examine thoroughly the emery of this island, which promises to be of importance to the arts. It is only within about twelve months that it has been brought to light. The mineral of this locality presents some peculiar features which will be alluded to hereafter. The geology is the same as that of the other localities already alluded to, namely, when found in contact with the rock it is always with limestone.

Island of Samos.—This locality has furnished me with only a few nodules imbedded in the soil with a little calcareous rock attached to the surface.

Island of Naxos.—This old and well known locality is here alluded to, simply because it has furnished me with specimens, the examination of which forms a part of this memoir. It is found in large blocks mixed with a red soil and also imbedded in white marble. It is taken principally from the north and east side of the island—the best comes from *Vothrie*, nine miles from the shore, and is embarked at *Sulionos*. Another good locality is at *Apperanthos*, seven miles from the shore, and it is embarked at a small port called Moutzona. In the south of the island it is found near *Yasso*. It is in such abundance on this island, that notwithstanding the immense quantity carried off it is not yet found necessary to quarry it from the rock.

Conclusions with reference to the Geology of Emery.

The localities at Gumuch-dagh and Kulah are those which afforded me the best means of studying the geology of emery, although in every instance I have found it associated with the old limestone overlying mica slate, gneiss, &c.

It is imbedded either in the earth that covers the limestone or in the rock itself; and exists in masses from the size of a pea to that of several tons weight, generally angular, sometimes rounded, and when in the latter form they do not appear to have become so by attrition.

The masses in the soil possess but little interest for the geologist, as they may have been left there by the decomposition of the rock, or been transported from other positions; still, the latter is difficult of supposition, in reference to what is found at *Gumuch-dagh*, for here it is only on the summit and not on the sides of the mountain that the emery has been traced. But having had the means of studying the emery and rock in contact, I have come to the firm conclusion, that the *emery has been formed and consolidated in the limestone in which it is found*, and that it has not been detached from older rocks as granite, gneiss, &c., and lodged in the limestone at the period of its formation. My reasons for so thinking are the following—

1st. In no instance could the closest investigation of the older rocks of these localities, that are below the limestone, furnish the slightest indication of the existence of emery there; and moreover the masses of emery in the limestone never had fragments of another rock attached to them. A few thin layers of mica slate were found in the limestone, but they were not in contact with the emery, nor contained any traces of corundum. I dwell thus much on this point, because in my specimens the calcareous rock in connection with the emery is under two forms; that of the original rock, and that formed by the infiltration of calcareous water in the fissures which exist near the surface.

2d. The limestone immediately in contact with the emery differs almost invariably in color and composition from the mass of the rock; and at *Kulah*, where the marble forming the rock is remarkably pure (as evinced by analysis), the part in contact with the emery is of a dark yellow color resembling spathic iron, and contains a large portion of alumina and oxyd of iron. The thickness of this interposing coat between the emery and the marble is variable; but what is certain, it passes gradually into white marble, so that their crystalline structures run into each other, showing that they are one and the same rock. Had the masses of emery been broken from an older rock and imbedded in the marble at its formation, there is no reason why the contact should not always be direct and immediate without this transition from ferro-aluminous limestone to pure marble. What we see is just what should be expected in ferruginous and aluminous minerals forming and separating themselves from a limestone not yet consolidated.

This kind of separation between the emery and the marble has been highly useful in the facility that it has indirectly afforded for exploring this mineral. It has been stated that at all the localities under consideration, but principally at Gumuch and Naxos, the emery exists in great abundance detached from the rock in a red earth; now this earth is simply the result of the decomposition of this heterogeneous calcareous envelope, which from its nature is easy of disaggregation by the influence of atmospheric agents. Had the emery been in immediate contact with the marble we could hardly have expected this spontaneous separation in so great a quantity.

I have in some instances seen small nodules of emery in small cavities in the rock but perfectly detached.

3d. The immense mass alluded to as covering several square yards of surface is another evidence of the emery having been formed in the limestone; for this mass does not consist of a single piece, but of a number of different sizes, not lying together irregularly, but with their contiguous surfaces more or less parallel, although removed a little distance from each other; in fact, it is just what we would expect in a large mass that for some cause or other had been fissured in various directions.

4th. Yet another circumstance to be remarked in connection with this part of the subject, is, that in the examination of the surface of contact between the emery and the rock, we do not always see it marked by a distinct outline; but the minerals constituting the emery as well as those associated with it, are more or less disseminated in the limestone at the point of contact; the value of this argument is better understood on examining the specimens in my possession.

Enough having been said to prove that the emery under consideration was formed within the limestone in which it is found, I will allude to the process of segregation which has given rise to this formation.

It would appear that the substances eliminated from the calcareous rock, were silica, alumina, and oxyd of iron, and that these three in the exercise of homogeneous and chemical attractions have given rise to the minerals which constitute and are associated with emery. In my collection, there is a specimen exhibiting this fact in a remarkable manner. It is a nodule, showing emery in the center, with two concentric layers, the inner of *chloritoid* and the outer of *emerylite;* the latter was in contact with the limestone.

Emery—mixture of corundum (alumina a little hydrated) and oxyd of iron.

Chloritoid—silica 24, alumina 40, oxyd of iron 28, water 7.
Emerylite— " 30, " 50, lime 13, water 5.

It is seen that in commencing from the external surface, in which direction we must regard the consolidation of the nodule, that the larger portion of silica eliminated has combined with a large portion of alumina and some lime to form a peculiar mineral; next, the remainder of the silica combines with an additional quantity of alumina and considerable oxyd of iron to form another mineral; and finally the remaining alumina and oxyd of iron crystallize separately. Facts of this kind in geology are not unfrequent, but they are always highly interesting and worthy of remark.

In concluding the geological considerations of emery with reference to the localities in Asia Minor and the neighboring islands, I would remark, that at some future time when the observations become extended, it will doubtless be found that the emery forms the geognostic mark of extensive calcareous formations in that part of the world, just as the flints do in the chalk of Europe.

Mineralogical position of Emery.

Emery has been considered by some as corundum, others suppose it represented by some rock or other, not always the same, in which corundum is disseminated in greater or less quantity; others again consider it a mixture of corundum and oxyd of iron. I am of opinion that the latter is the most correct manner of regarding this substance.

Emery properly speaking is not a simple mineral, but a mechanical mixture of granular corundum and oxyd of iron in which the former usually predominates. It has not the aspect of corundum disseminated in a rock, for it is found in distinct masses of different dimensions and of great hardness; and when broken giving way in the directions of fissures, which exist commonly in the mass. Most frequently there is no other evidence of the presence of corundum in emery but its hardness. The oxyd of iron present is always under the form of magnetic oxyd more or less mixed with oligiste; sometimes it is titaniferous. There are other minerals associated with the emery, all of which will be described hereafter.

The aspect of this substance differs more than is supposed, for until lately, the emery brought from Naxos has been the criterion by which to judge others. The localities that I have discovered furnish me with specimens showing considerable difference not only as regards color but also in the structure.

The *Naxos emery* is of a dark grey with a mottled surface, and with small points of a micaceous mineral disseminated in the mass. It frequently contains bluish specks or streaks which are easily recognized as being pure corundum.

The *Gumuch-dagh emery* is commonly of a fine grain and dark blue bordering on black, not unlike certain varieties of magnetic iron ores. With this variety we frequently find pieces of corundum of some size. The interior of the mass is tolerably free from the micaceous specks found in that of Naxos.

The *Kulah emery* is usually coarse grained, and much darker than that of Gumuch-dagh, its external surface resembling sometimes that of chromate of iron.

The *Nicaria emery* in many instances presents a schistose or lamellated structure to a very remarkable degree, so much so that certain specimens might pass for gneiss. The color is dark blue and somewhat mottled like that of Naxos. There is also much that is quite compact found in the same locality. The lamellated variety contains an abundance of a micaceous mineral, which in this instance appears to have determined its structure.

The *Samos emery*, as yet found only in small quantities, and in the form of nodules, is uniformly of a dark blue color, sometimes of a coarse grained and at other times of a fine grained structure not unlike certain varieties of very compact blue limestone.

Fracture.—The fracture of emery is tolerably regular, and the surface exposed is granular of an adamantine aspect; it is exceedingly difficult to break when not traversed by fissures or not of a lamellated structure as much of that from Nicaria. When reduced to powder it varies in color from that of a dark grey to black. The color of its powder affords no indication of its commercial value.

The powder examined under the microscope shows the distinct existence of the two minerals, corundum and oxyd of iron, which appear inseparable as the smallest fragment contains the two together.

Magnetism.—As it is natural to suppose all specimens of emery affect more or less the magnetic needle; in some the magnetism is barely perceptible, in others it amounts to strong polarity.

Odor.—Emery when moistened always affords a very strong argillaceous odor; even the most compact varieties.

Specific gravity.—The different varieties do not vary much in their specific gravity, it being always in the neighborhood of 4. The specific gravity of various specimens will be given on a following page.

Hardness.—The hardness of emery is its most important property, as to it is due the value of this substance in the arts. For this reason I have devoted much time and attention to the determination of it. In a mineralogical sense its hardness is not difficult to determine; for if we try different varieties of emery by scratching agate or other hard substance, the effect will naturally be very nearly the same; for in every case, it will be some point of corundum that has produced the scratch. If, however, we happen not to rub a point of corundum against the agate no effect will be produced on the latter, but the emery will yield. As this method leads to no practical result, I have sought out another, which may be properly called one for determining the *effective hardness of emery and corundum*, and is as follows.

Fragments are broken from the piece to be examined, and crushed in a diamond mortar with two or three blows of a hammer, then thrown into a sieve, (the one employed had 400 holes to the square centimetre,) the portion passing through is collected, and that remaining on the sieve is again placed in the mortar and two or three blows given, then thrown into the sieve; the operation is repeated until all the emery has passed through the sieve. The object of giving but two or three blows at a time is to avoid crushing any of the emery to too fine a powder.

Thus pulverized it is intimately mixed and a certain portion of it is weighed, (as I operated with a balance sensible to a milligramme, the quantity used never exceeded a gramme.) To test the effective hardness of this, a circular piece of glass about four inches in diameter and a small agate mortar are used. The glass is first weighed and placed on a piece of glazed paper; the pulverized emery is then thrown on it little by little, at each time rubbing it against the glass with the bottom of the agate mortar.

The emery is brushed off the glass from time to time with a feather, and when all the emery has been made to pass once over the glass, it is collected from the paper and made to pass through the same operation which is repeated three or four times. The glass is then weighed, after which it is subjected to the same operation as before, the emery being by this time reduced to an impalpable powder. This series of operations is continued until by repeated weighing the loss sustained by the glass is reduced to a few milligrammes. The total loss in the glass is then noted, and when all the specimens of emery are submitted to this operation under the same circumstances, we get an exact idea of their relative hardness.

The blue sapphire of Ceylon was pulverized and experimented with in this way; it furnished me with a unit of comparison by which to compare the results obtained. This operation is long but certain, and for the harder varieties of emery it is necessary to repeat the rubbing six or seven times and it requires nearly two hours for completion.

The results that I have obtained are interesting and have furnished me with the means of forming conclusions that I could not have otherwise come at.

Glass and agate have not been chosen for this experiment without a certain object, as experiments were first made with two pieces of agate, with two pieces of glass, and with metal and glass. The agates were found too hard, as they crushed the emery without producing hardly any abrasive effect; the others were found not to crush the emery sufficiently, making the experiment tedious and long. With the glass and agate we have a hard substance which crushes the emery, and in a certain space of time reduces it to such an impalpable state that it has no longer any sensible effect on the glass, and on the other hand, the glass is soft enough to lose during this time sufficient of its substance to allow of accurate comparative results. In the employment of this method in the arts, it would not be necessary to go to the sapphire for a standard of comparison; any good emery would answer the purpose quite as well.

It must be understood that this method of coming at the abrasive effects of emery does not furnish the mineralogical hardness of this substance, by which we understand the hardness of any individual particle, as evinced by its effect on a substance of less hardness, without regard to the molecular structure of the mineral. Two minerals possessing the same hardness but differing in structure, one being friable, and the other resisting, will be found very different in their abrasive effects; for instance, break a piece of quartz in two, subject one of the pieces to a white heat, and after cooling, compare the two by rubbing the point against some hard substance; both will be found to scratch equally well: then try the two in a state of powder, by rubbing them between two pieces of glass that have been weighed, and the difference of their abrasive effects will be found very great; because, the one subjected to the fire is exceedingly friable, and becomes readily crushed to an impalpable powder. This fact is eminently true with reference to emery, many specimens of which containing the same amount of corundum differ somewhat in their *effective* *hardness* owing to the more or less compact structure of the corundum.

By the method with the agate and glass I have found the best emery capable of wearing away about one-half its weight of the glass (that used was the common French window glass). The sapphire under the same circumstances wears away more than four-fifths of its weight. A tabular view of the results will be given a little farther on.

Chemical composition of Emery.

This substance consisting of a mixture of corundum and oxyd of iron in various proportions, it is easy to see what its composition must be. Yet the chemical examination of this mineral taken in connection with other properties is not devoid of interest.

For the purpose of analysis, the emery was reduced to a state of powder, in the manner alluded to in speaking of its hardness, with a diamond mortar and sieve. This powder was dried for twenty-four hours over sulphuric acid; a gramme was then weighed in a small platinum crucible of about one-fourth of a cubic inch in capacity, fitted with a cover that adapted itself well to it; this small crucible was placed in another of earth, and the space between the two filled with pulverized quartz which also covered the smaller one to the depth of half an inch. Common sand was not used, because during the heating some particles might adhere to the platinum crucible by a semifusion; nor was powdered charcoal employed because it protected the mineral no better than the pulverized quartz from contact with the air, at the same time a little risk was run in decomposing a small amount of the iron.

Thus arranged the crucibles were heated to a bright red for from thirty minutes to one hour. After cooling, the platinum crucible was carefully withdrawn and weighed. The loss furnished me with the amount of water in the emery.

It requires a continued red heat to drive out all the water, a circumstance which is true for a number of minerals, particularly for those containing a large amount of alumina as diaspore and the micas which will be spoken of in this paper.

The powder, of which the water has been estimated, was next submitted to levigation in a large agate mortar placed on a surface of glazed paper: and when completed, it was carefully detached from the mortar, placed in a platinum capsule, heated gently to drive off any hygrometric moisture and weighed; the increase of weight furnished the amount of silica taken from the mortar.

The levigation of one gramme was accomplished in two operations, each requiring about twenty minutes; and by using a mortar of convenient size and the extremity of a feather or a small brush, it is possible to lose but an insensible quantity of the mineral and to estimate with sufficient precision the amount of silica abraded from the mortar.

Another method by which I accomplished the levigation in some of the analyses, was in a steel mortar of the same form as the agate mortar; and when completed the powder was placed in a glass with nitric acid diluted with thirty times its weight of water and left in it for one hour agitating it occasionally. The iron taken from the mortar was dissolved, and no part of the mineral attached. The next thing was to filter and continue the analysis with the substance thus freed from the iron of the mortar, without any second weighing.

Of these two methods I preferred to employ the first for the emery, as it is more expeditious and almost if not quite as exact as the second. There are, however, occasions in which the steel mortar should be resorted to.

The substance once reduced to an impalpable powder, it was necessary to render it *completely* soluble, and my researches to arrive at this were long and tedious. In trying the various known methods the most successful was found to be that with a mixture of carbonate of soda and caustic soda heated to whiteness for one hour; nevertheless I could not obtain a complete decomposition. The decomposition might probably be completed if the levigation was made more thoroughly, but it is easy to understand, that with a large number of analyses of the same substance to make, it was a desideratum on my part not to consume the best part of a day in the levigation of a single gramme; particular, as I did not wish to confide this operation to another, as much care was required to lose nothing during the levigation. Mixed with carbonate of baryta and heated in a forge, the decomposition of the mineral was far from being complete; the same may be said for the treatment with the caustic alkalies in a silver crucible.

The bisulphate of potash decomposes it almost entirely by a single operation, but unfortunately, a double salt of potash and alumina is formed which is almost insoluble in water or in the acids, and it is only by a solution of potash that it is first decomposed and afterwards redissolved. I will not stop to detail all the disadvantages attending this method, but will at once speak of the method which gave me very easily the most accurate results.

It is by means of the bisulphate of soda that all my analyses of emery, of corundum, and of several aluminates were made. I believe that I am the first who has shown the great advantage of using this double salt in the decomposition of certain substances insoluble in the acids; and very probably it will replace in most cases the use of the bisulphate of potash in analytical chemistry. At present, all the advantages that may arise from the substitution of the soda for the potash salt cannot be mentioned; all that I will say is, that the former in giving a decomposition at least as complete as the latter, furnishes a melted mass quite soluble in water, and in the future operations of the analyses there is no embarrassment from a deposit of alum.

The bisulphate of soda was prepared by adding an excess of pure sulphuric acid to the pure carbonate or neutral sulphate of soda and heating it in a capsule until all the water had been expelled and sufficient of the acid to allow of the mass becoming solid on cooling. That obtained in commerce is not sufficiently pure.

The pulverized emery is placed in a large platinum crucible with six or eight times its weight of bisulphate of soda, and the mixture is heated over a lamp in the same manner and with the same precautions as are employed when using the bisulphate of potash. From fifteen to thirty minutes suffice for the operation. The mass is allowed to cool, and water with a few drops of sulphuric acid are added to it and the whole heated, when it soon dissolves with the exception of a little silica, that renders the solution milky, and a small quantity of undecomposed mineral, that is readily detected by rubbing a glass rod against the bottom of the capsule. The liquid is now filtered, and the filter is washed once with a little water; then with its contents it is placed in a platinum crucible, burnt completely, and the residue is heated with a little bisulphate of soda, which completes the decomposition: and when treated with water and a drop or two of sulphuric acid all except the silica is dissolved. The liquid which passes the filter in this case is added to the first and the analysis continued. The silica obtained is diminished by the quantity taken up from the mortar in order to arrive at what is actually contained in the mineral. The filtered solution is heated with a little nitric acid to convert all the protoxyd of iron into peroxyd, then treated with an excess of caustic soda and a little carbonate of the same alkali; this redissolves the alumina first precipitated and thus separates it from the oxyd of iron and a trace of lime. The iron and lime are separated in the ordinary way; the alkaline solution of alumina was acidulated and the alumina precipitated with carbonate of ammonia.

Thus analyzed, the emery from different places gave the following results:—

No.	Localities.	Effective hardness. Sapphire 100	Specific gravity.	Chemical composition.					
				Water.	Alumina.	Oxyd of iron.	Lime.	Silica.	Total.
1	Kulah,	57	4·28	1·90	63·50	33·25	0·92	1·61	101·18
2	Samos,	56	3·98	2·10	70·10	22·21	0·62	4·00	99·03
3	Nicaria,	56	3·75	2·53	71·06	20·32	1·40	4·12	99·43
4	Kulah,	53	4·02	2·36	63·00	30·12	0·50	2·36	98·34
5	Gumuch,	47	3·82	3·11	77·82	8·62	1·80	8·13	99·48
6	Naxos,	46	3·75	4·72	68·53	24·10	0·86	3·10	101·31
7	Nicaria,	46	3·74	3·10	75·12	13·06	0·72	6·88	98·88
8	Naxos,	44	3·87	5·47	69·46	19·08	2·81	2·41	99·23
9	Gumuch,	42	4·31	5·62	60·10	33·20	0·48	1·80	101·20
10	Kulah,	40	3·89	2·00	61·05	27·15	1·30	9·63	101·13

I ought to mention that the analysis afforded other substances in small quantities in some of the emeries; as titanic acid, oxyd of manganese, oxyd of zirconium, and sulphur (existing in pyrites); but these substances are unimportant in the composition of emery, and are in such minute quantities, that it is necessary to operate on a considerable quantity of the mineral to obtain satisfactory results concerning them.

The analyses marked 6 and 8 were made by decomposing the emery as it came from the sieve, without pulverization in the agate mortar. It was by accident that it occurred and I was not aware of the neglect until it was fused with the bisulphate of soda, but not wishing to lose the analysis, the operations were continued as in the other cases, only using a little more of the bisulphate in the second decomposition; and somewhat to my surprise, the decomposition was quite as perfect as in the other cases. I had nearly completed all my analyses in the manner detailed, when this fact became known, so that I have but these two cases to report. It will simplify the analysis of corundum if pulverization in a diamond mortar be found sufficient, and I propose examining specially into this question.

The water which was found in the emery comes from the corundum, a fact which will be shown when the analysis of pure corundum is given, which will be in the second part of the memoir. A very minute quantity of what has been estimated as water might be a little oxygen lost by the oligiste which is sometimes found in emery. Those emeries which contain the least water, every thing else alike, are the hardest, as instanced by that from Kulah, notwithstanding the quantity of iron it contains. The silica existing in emery is most often in combination with alumina or the oxyd of iron or with both, for this reason we must not always regard the quantity of alumina as an indication of the quantity of corundum in the emery.

Analogies.

Emery at first sight may be confounded with several ores of iron; as magnetic iron, certain varieties of oligiste and sometimes with chromate of iron; but the fracture of emery is stony which differs from these ores of iron, and besides the surface exposed is of a lighter color. From the numerous observations made, I may set it down as a general rule, that any blackish or dark blue rock of a strong argillaceous smell, that scratches agate easily, with a specific gravity in the neigborhood of 4, is sure to be emery.

The mining of Emery.

The mining of this substance is of the simplest character. The natural decomposition of the rock in which it occurs facilitates its extraction. As has already been mentioned, the rock decomposes into an earth in which the emery is found imbedded. The quantity found under these favorable circumstances is so great that it is rarely necessary to explore the rock. The earth in the neighborhood of the blocks of emery is almost always of a red color, and serves as an indication to those who are in search of the mineral. Sometimes before beginning to excavate, the spots are sounded by an iron rod with a steel point, and when any resistance is met with, the rod is rubbed in contact with the resisting body, and the effect produced on the point enables a practised eye to decide whether it has been done by emery or not.

The blocks which are of a convenient size are transported in their natural state, but most frequently they are required to be broken by means of large hammers; when they resist the hammer, they are subjected to the action of fire for several hours, and on cooling they most commonly yield to blows. It, however, happens sometimes that large masses are abandoned from the impossibility of breaking them into pieces of a convenient size; as the transportation either on camels or horses requires that the pieces do not exceed one hundred pounds.

At Kulah, the quantity of emery detached from the rock was not very considerable, as it had been protected from decomposition by the beds of lava that cover it. Here the marble was quarried to get at the emery which was done in the early part of 1847 with profit, although the transportation from Kulah to Smyrna is over a distance of one hundred and ten miles on the backs of camels. Since the diminution of the price of emery, this mine has been abandoned, for the quarrying into the marble is attended with the greatest difficulty as the tools used for boring, &c., are thrown out of use in a very short time, by the pieces of emery which are encountered at every instant. At present all the emery sent from Asia Minor comes from the mine at *Gumuch-dagh*, twelve miles from the ruins of *Ephesus.*

Commercial consideration of Emery.

The use of emery in the arts is of very ancient date, a fact proved by works on hard stones that could not have been executed except by emery or minerals of that nature. It is very probable that emery coming from the localities which have been mentioned, was used in former ages by the Greeks and Romans. For example, the locality of *Gumuch-dagh* is immediately by the ancient Magnesia on the Meandre, and between Ephesus and Tralles, twelve miles from each of these cities, and the same distance from Tyria; in all of these cities the arts flourished, and none more than that of cutting hard stones, if we are allowed to judge from the specimens of their skill in this art that have come down to us.

Nevertheless, the quantity of emery formerly employed was insignificant in comparison to the quantity now required, more particularly within the last twenty years, since the use of plate glass has been extended. The annual consumption at the present time is about *fifteen hundred tons.*

For various reasons, the island of Naxos furnished for several centuries almost exclusively the emery used in the arts, as much for the facility with which it was obtained as for the uniformity of its quality. The emery exists in very great abundance on this island, and notwithstanding the quantity already extracted there still remain immense deposits of it.

The price of this substance at the end of the last century was from 40 to 50 dollars the ton, and between 1820 and 1835 it was at times even less. About this period, the monopoly of the Naxos emery was purchased from the Greek government by an English merchant, who so regulated the quantity given to commerce that the price gradually rose from 40 to 140 dollars the ton, a price at which it was sold in 1846 and 1847. It was at this time that I commenced examining and developing the emery formations of Asia Minor until then unknown. And after making a report to the Turkish government, the monopoly of the emery of Turkey was sold to a mercantile house in Smyrna, and since then the price of this article has diminished to 50 and 70 dollars the ton according to the quality. I speak of the prices in the English market.

The different mines explored are those of *Naxos* of an ancient date, of *Kulah* commenced in 1847 and now abandoned for those nearer the sea, of *Gumuch-dagh* commenced in 1847 and worked largely, and of *Nicaria* commenced in 1850. From all these different places the emery goes to Smyrna, and from there, principally to England, the vessels taking it at a very low price as it serves for ballast.

The various mines belong to the Turkish and to the Greek government. The Greek government now sells its emery in lots of several tons. The Turkish government sells the entire monopoly of its mines, and consequently its operations are controlled by a single interest; but in all probability, this monopoly will be done away with, in virtue of a commercial treaty existing between Turkey and the other powers. If this takes place the price of emery will be still farther diminished.

Of the different varieties of emery employed in the arts that of *Naxos* is still preferred, and with reason, as it is more uniform in its quality than that coming from *Kulah* and *Gumuch;* nevertheless, if the best qualities of that from the island of *Nicaria* are found in abundance and that only sent into market, it will prove at least equal if not superior to that of Naxos.

Second part.—*On the Minerals associated with Emery: Corundum, Hydrargillite, Diaspore, Zinc spinel, Pholerite, Ephesite* (a new species), *Emerylite* (a new species), *Muscovite, Chloritoid* (a new variety), *Black Tourmaline, Chlorite, Magnetic Oxyd of Iron, Oligiste Iron, Hydrated Oxyd of Iron, Iron Pyrites, Rutile, Ilmenite and Titaniferous Iron.*

Read before the Academy of Sciences of the French Institute, [illegible]h, 1850, and communicated by the author for this Journal.

Now that it has been shown that emery is found in considerable abundance in certain parts of the world,* occupying almost the position of a rock; it is useful to mention the different accidental minerals or *minerals of elimination*, that are found with emery, and what new facts have been observed with relation to them. Corundum may be first mentioned.

Corundum.—Although emery is constituted principally of corundum, the examination of this substance in its pure state, or rather in the form of these prismatic crystals which I have sometimes found in contact with emery, has brought to light several new and well established facts that could not have been satisfactorily ascertained from a mixed mineral like emery.

At *Gumuch-dagh*,† it is not difficult to find large pieces of this mineral, pure or mixed with a little diaspore and emerylite: sometimes the crystals are very distinct, under the form of six-sided prisms. The small crystals found in the cavities are sometimes terminated by a summit of six faces. The color of the corundum found in the different places alluded to in this memoir, is blue, except that of Kulah and of Adula, which is of a greenish grey. All that I have to add to what is already known of this mineral,

* For the *First Part* of this memoir, see the last volume of this Journal, pages 354–369.

† See the *first part* of this memoir for a description of the localities, this Journal, x, 354.

relates to its *composition* and *effective hardness:* the latter was ascertained in the way already described in speaking of the emery, and it has been found to vary with the composition of the mineral. The analyses were made in the same manner as those of the emery, and the results which I have obtained are as follows:—

	CORUNDUM.		COMPOSITION.					
Localities.	Effective hardness. Sapphire 100.	Sp grav.	Water.	Alumina	Magnetic ox. iron.	Lime.	Silica.	Manganese.
Sapphire of India, ...	100	4·06	——	97·51	1·89	——	0·80	——
Ruby of India, ...	90	——	——	97·32	1·09	——	1·21	——
Corundum of Asia Minor,	77	3·88	1·60	92·39	1·67	1·12	2 05	trace.
Corundum of the island of Nicaria, ...	65	3 92	0·68	87·52	7·50	0·82	2·01	——
Corundum of Asia,....	60	3 60	1·66	86·62	8·21	0·70	3·85	——
Corundum of India,....	58	3 89	2 86	93·12	0·91	1·02	0·96	——
Corundum of Asia,....	57	3·80	3·74	87·32	3·12	1·00	2·61	——
Corundum of India,....	55	3·91	3·10	84·56	7·06	1·20	4·00	0·25

The most remarkable fact ascertained by these analyses, is the presence of water in variable quantity in all varieties of the corundum except the sapphire and ruby. To me this fact has a certain value in proving that the corundum and the sapphire are formed under different circumstances and do not belong to the same geological formation. The different structure of these two species of corundum might make one suspect a difference in the condition of their formation; and this is somewhat confirmed by the results of the beautiful experiments of M. Ebelmen in making artificial corundum by subjecting alumina and borax to the heat of a porcelain furnace for many hours; circumstances under which he always obtained crystals under some of the modifications of hyaline corundum, and never as prismatic corundum. In addition to this, I remark that in my most thorough examination of the localities of emery, not the slightest trace of sapphire or ruby was found.

The quantity of water found to exist in corundum, coming from different localities, is variable, and it would appear that all other things equal, those containing the least water are the hardest. I will not insist on the slight difference between the hardness of the sapphire and ruby, having made only one experiment upon each of these minerals.

The two varieties of corundum are so evidently united by their system of crystallization, that I would not undertake to separate them on account of the presence of water in one of them, and that in variable quantity: nevertheless, the fact is important as it explains to a certain extent their differences in structure and hardness. I would remark that great pains was used to ascertain whether the water might not be due to the presence of diaspore or some other hydrate of alumina; but after the most careful and repeated examinations, this has been decided in the negative.

Hydrargillite.—Hydrargillite is rarely met with. I have one specimen with this mineral forming the external coating of a crystal of corundum, and also a hexagonal prism of the same mineral. It was not analyzed, but its physical properties and its reactions under the blowpipe served to prove its identity with this mineral. The specimen in my possession comes from *Gumuch-dagh.*

Diaspore.—This mineral up to the present time has not occupied a very important position in mineralogy, and has been found only in two or three localities. In the course of this article, I hope to show that it plays a somewhat important part in the emery and corundum formations. Before my attention was drawn to the mineral, first discovered by M. Lelievre, it was studied by M. Dufrenoy, on that coming from Siberia, and by M. Haidinger on the diaspore of Schemnitz. Before going farther I would remark, that the gangue of the latter which has been described as analogous to steatite, was found by me not to be such, but a hydrated silicate of alumina, similar to one found with the emery of Naxos.*

To the localities of diaspore already known, I have to add those of *Gumuch-dagh* and *Manser* in Asia Minor, and the islands of *Naxos*, *Samos*, and *Nicaria*, in the Grecian Archipelago; and there is reason to suppose that this mineral will be found in almost every corundum locality. I have already found it on crystals of corundum from China.†

In examining the emery formations, one of the first things that struck my attention was the existence of diaspore and corundum together, then observed for the first time. The same year, M. Marignac discovered it in the limestone of St. Gothard, along with the well known crystals of corundum that exist there. Having found the diaspore under these new circumstances it has been examined with much attention.

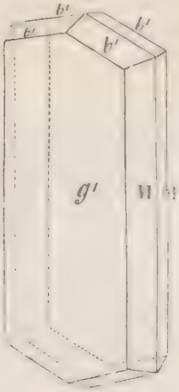
At Gumuch-dagh the diaspore is found in flattened and rounded prisms with the surface streaked with lines that afford by reflected light an iridescence. Crystals with perfect summits are rarely found, and during two or three days examination on the place I found only five small crystals with one of the summits perfect, they were however, very beautiful and finer probably

* The gangue of the Schemnitz diaspore has been examined by Hutzelmann, see this Journal, [2], x, 247, and Pogg. Ann., lxxviii, 575, who makes it to contain three distinct hydrates of alumina; but this fact cannot be considered as sufficiently established. One of these hydrates is named *Dillnite*, and another is near Agalmatolite.

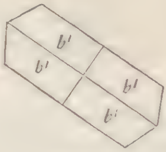
† Prof. C. U. Shepard has found diaspore with topaz at Trumbull, Conn.

than any yet known. Not wishing to lose so favorable an occasion to verify the crystallography of diaspore, I requested M. Dufrenoy to undertake the measurement of the angles, and it is to this able professor that we are indebted for the crystallographic results here given.*

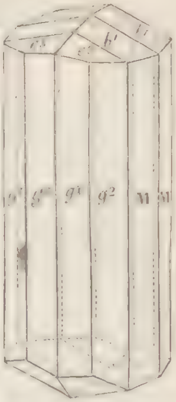
1.



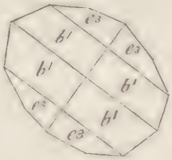
1 a.



2.



2 a.



The crystals are elongated needles crossing each other in all directions like an acicular variety of arragonite from the Vosges. They resemble small crystals of topaz in lustre and in the disposition of the vertical striæ on the faces g. Their color is yellowish white. They are strongly dichroitic, the summits under certain inclinations appear black as if the light was completely polarized. The cleavage is very easy parallel to the face g^1, and it is this cleavage that gives a lamellar structure to that diaspore which is not in the form of needles. This cleavage notwithstanding its facility does not expose surfaces that reflect with great accuracy; it is the only angle which offers the difference of a half degree; repeated measurements of the other angles never varied more than four minutes. The pearly lustre of the cleavage in connection with its striated character are the causes of this difficulty which at first sight would not appear to exist, only becoming evident when the angle is examined.

The crystals, very much flattened parallel to the face g^1, are represented by figures 2 and 3; the face g^1 does not exist, being replaced by three series of faces g, the angles of which could not be measured, but the almost absolute identity of these crystals with those of St. Gothard, which M. Marignac first described,

* Three of the crystals measured are in the Cabinet of the School of Mines and Garden of Plants at Paris.

The second crystal above is nearly as thin as the first, although represented thicker in order to show well all the planes.

authorizes one to suppose that they are represented by the crystallographic signs g^2 and $g^{\frac{1}{3}}$. The faces M and those of the summit have a very bright lustre. The primitive form of the diaspore is undoubtedly a right rhombic prism of 130° 2′; the fact that the base is horizontal, is shown by the identity of the angles of the faces b^1 on the anterior faces M, and the faces b^1 on the posterior faces of the same. This position is verified in seeking for the angle of the edge b^1 on M, which ought to be a right angle; in fact the calculation of a spherical triangle composed of the faces M, b^1 and g^1, of which all the angles of incidence were measured, gave for this edge 90° 2′ 30″, which differs from a right angle by only two minutes and a half.

The following table is made up of the measurements of the angles of the diaspore of Gumuch-dagh (near Ephesus) by M. Dufrenoy, of that of St. Gothard by M. Marignac, and of that of Schemnitz by M. Haidinger, also the measurement of some angles of the hydrated peroxyd of iron of Cornwall, by M. Dufrenoy, which are here given to show an interesting connection, first pointed out by M. de Senarmont, and which consists in the isomorphism of diaspore and the hydrated oxyd of iron. Thus while the peroxyd of iron or oligiste iron is isomorphous with alumina or the corundum, the hydrates of the same oxyds are isomorphous.

	Diaspore of St. Gothard, *Marignac.*	Diaspore of Schemnitz, *Haidinger.*	Diaspore of Gumuch-dagh near Ephesus, *Dufrenoy.**	Hydrated Oxyd of Iron, of Cornwall, *Dufrenoy.*
M : M	130°	129° 54′	130° 2′	130° 57′
M : b^1	....	....	125° 17′	
M : b^1 (posterior faces),	....	....	125° 18′	
M : g^1	115°	....	114° 58′	
b^1 : g^1	104° 12′	....	104°	
b^1 : b^1	151° 36′	151° 36′	151° 35′	
b^1 : b^1 (posterior faces),	....	....	151° 33′	151° 34′
b^1 : b^1 (opposite faces),	116° 38′	....	116° 18′	
b^1 : c^3	....	....	167° 6′	
g^1 : g^2	144° 40′	....		
g^2 : g^2	145° 40′	....		
i : i	126° 12′	....	....	126° 20′
g^1 : i	116° 56′	....	....	116° 55′
$e^{\frac{1}{2}}$: $e^{\frac{1}{2}}$	117° 46′	....	....	117° 10′

I have found crystals of diaspore in hydrated oxyd of iron, the needles traversing the oxyd in all directions. There is a specimen in my possession composed of a small crystal of diaspore, surrounded by a kind of scabbard of crystallized göthite; one of the summits of the crystal is exposed. In breaking the oxyd of iron which contains these crystals, they become detached, leaving on the oxyd an impression with a very brilliant surface.

* The values of these angles are just as given by the goniometer without any correction by calculation.

The diaspore of Gumuch-dagh is also found, of a lamellar structure, but very rarely: that of Naxos, Nicaria and Samos are all lamellar. Yet of all the specimens that I have collected none offer so much interest as those composed of diaspore imbedded in corundum; here we see the two minerals passing one into the other, without being able, in many places, to distinguish the line of separation, so imperceptible is the gradation. After what has been said in respect to corundum, it is not astonishing to see this connection of alumina more or less hydrated with a hydrate of alumina of definite composition.

After a knowledge of this fact one might seek to explain the existence of water in corundum, by the intimate mixture of diaspore with this mineral: if this be the case, the crystal of corundum from the Carnatic, which gave me three per cent. of water, must contain twenty-three per cent. of diaspore, although neither the eye nor microscope could detect its presence.

As to the properties of diaspore, I have nothing to add to what has already been published on the subject, except that the specimens I examined do not decrepitate to the same extent as that of Siberia. Its specific gravity is 3·45 and hardness above 7. The following analyses were made, the mineral being attacked with the bisulphate of soda. They afford the formula, $\ddot{Al}\,\dot{H}$.

Localities.	Silica	Alumina.	Lime.	Oxyd of Iron.	Magnesia.	Water.
Gumuch-dagh,............	0·67	82·20	0·41	1·20	*trace:*	14·52
Gumuch-dagh,............	0·82	83·12	*trace.*	0·66	*trace.*	14·28
Naxos,..................	0·26	82·94	0·35	1·06		14·81

Zinc Spinel.—I possess a single specimen of this spinel in chloritoid on a piece of emery from Gumuch-dagh: it is in octahedral crystals agglomerated, of a dark emerald green color: the quantity being small I have been prevented from making an exact analysis. The quantity of oxyd of zinc appears to be from thirty to forty per cent.

Pholerite.—A mineral, resembling pholerite in composition, has been found with the emery of Naxos associated with emerylite. It is white, lamellar, and somewhat crystalline, sometimes grey. It is soft to the touch like steatite, infusible before the blowpipe, and when heated with nitrate of cobalt becomes strongly colored blue. It is scratched with the nail, and has a specific gravity of 2·564. Its composition is identical with the pholerite of Guillemin, also with the mineral forming the gangue of the diaspore of Schemnitz. For analysis it was decomposed with carbonate of soda. It afforded:—

		Pholerite of Guillemin.	Gangue of diaspore of Schemnitz—Smith.
Silica,	44·41	42·93	42·45
Alumina,	41·20	42·07	42·81
Lime,	1·21		*trace* and mag. *trace.*
Water,	13·14	15·00	12·92

This corresponds to the following formula, $\dddot{Si}\,\dddot{Al}+2\dot{H}$, but it is a question whether or not we should consider the water as existing in any definite proportion, and whether or not they did not all contain more water when first taken from their localities. These hydrated silicates of alumina are numerous, and bear various names, but it is doubtful if many of them are entitled to much consideration as distinct species.

Ephesite, (a new species.)—This silicate is found with the emery of Gumuch-dagh and occurs on specimens of magnetic oxyd of iron. It is of a pearly white color, and lamellar in structure; cleavage difficult. It scratches glass easily, and has a sp. grav. of from 3·15 to 3·20. Heated before the blowpipe it becomes milk-white, but does not fuse. At first sight it might be taken for white disthene. It is decomposed with great difficulty by carbonate of soda even with the addition of a little caustic soda. I used also very successfully in the analysis the bisulphate of soda either in attacking the mineral from the commencement, or in operating first with carbonate of soda, and then acting on the part not decomposed with bisulphate of soda. The alkalies were separated by means of hydrofluoric acid.

Silica,	31·54	30·04
Alumina,	57·89	56·45
Lime,	1·89	2·11
Protoxyd of iron,	1·34	1·00
Soda with a little potash,		4·41
Water,	3·12	3·06

This corresponds very nearly to the formula

$$\dot{R}^2\,\dddot{Si}+5\dddot{Al}^2\,\dddot{Si}+4\,\dot{H}.$$

	Atoms.	At. weight.	Pr. ct.	Oxygen ratio.
Soda,	2	781·6	7·08	1
Silica,	6	3400·2	30·77	9
Alumina,	10	6416·2	58·08	15
Water,	4	450	4·07	2

This mineral has been designated *Ephesite* because of its occurrence at the emery locality near the ancient city of Ephesus.

Emerylite. (a new species.)—This mineral which I have designated by the name of Emerylite is a new species belonging to the family of micas. I have already published a note indicating its existence,* but have reserved for the present time a complete description of it.

I first discovered this mineral with the emery of Gumuch-dagh in Asia Minor, and subsequently in that of Manser, the islands of Naxos and Nicaria, and also with the emery of Siberia.

* See this Journal, 2nd ser., vii, 285, 1849.

Its connection with all the emerys that have come under my observation except that of Kulah, induced me to call it *Emerylite.* When I announced this discovery to Prof. Silliman, Jr., he hastened to examine the minerals coming from the corundum localities of the United States, and has succeeded in finding the emerylite with the corundum of several localities.* The specimen from Siberia on which I found this mineral is in the collection at the Garden of Plants at Paris, and I have also reason to think that I have found it with the corundum of China.

The emerylite is lamellar like mica, the plates are easily separated, and possess a little elasticity. Sometimes it is in the form of a mass composed of very small pearly scales, which are very friable, resembling some species of talc. The plates are commonly convex and concave, grouped in such a manner as to form a triangular prism. I have also found it massive with a micaceous structure, but with an irregular fracture: the aspect of this variety is waxy: it comes from Gumuch-dagh. The crystalline form of this mineral is difficult to determine, but if we are permitted to judge from the streaks on the surface, and the imperfect cleavage in two directions, it would appear to belong to an oblique rhombic prism.

Its color is white and lustre silvery; the hardness taken on a specimen from the island of Nicaria is from 4 to 4·5. The sp. grav. taken on ten specimens varies from 2·80 to 3·09: this difference is not remarkable in a lamellated mineral. That which gave me the greatest specific gravity contained some small specks of titaniferous iron visible to the eye. Its optical properties have not been examined, for the want of a transparent piece of sufficient size and thickness. This mineral is not attacked by the acids; heated before the blowpipe it emits a bright light and melts with great difficulty on the edges, which assume a blue color if touched with the nitrate of cobalt and reheated. Heated in a tube it furnishes water frequently having an acid reaction due to fluoric acid.

The composition of several specimens subjected to analysis is as follows:—

Localities.	Silica.	Alumina	Lime.	Oxyd iron.	Magnesia.	Potash & soda	Water	Manganese.
Gumuch-dagh, ……	29·66	50·88	13·56	1·78	0·50	1·50	3·41	——
Island of Nicaria, …	30·22	49·67	11·57	1·33	*trace.*	2·31	5·12	——
" " ……	29 87	48·68	10·84	1·63	*trace.*	2·86	4·32	——
Island of Naxos, ….	30·02	49·52	10 82	1·65	0·48	1·25	5·55	——
" " ……	28·90	48·53	11·92	0·87	not estimat'd	not estimat'd	5·08	——
" " …..	30·10	50·08	10·80	not estimat'd	"	"	4·52	——
Gumuch-dagh, ……	30·90	48·21	9·53	2·81	"	"	4·61	——
" ……	31·93	48·80	9·41	1·50	"	2·31	3·62	*trace.*
Siberia, …………	28·50	51·02	12·05	1·78	"	not estimat'd	5·04	——

* See this Journal, viii, 379, and Dana's Mineralogy, pp. 362 and 689.

The oxyd of iron may be regarded as an impurity which exists between the plates of the mineral. The composition of the emerylite is represented by

	Atoms.	At. Weight.	Pr. ct.	Oxygen ratio.
Lime,	2	700·	13·48	2
Silica,	3	1700·1	32·74	9
Alumina,	4	2566·5	49·44	12
Water,	2	225·	4·34	2
		5191·6		

Formula, $\dot{R}^2\dddot{Si}+2\dddot{\bar{A}l}^2\dddot{Si}+2\dot{\bar{H}}$,

As is seen, the specimens examined came from four distinct localities, and were all taken under different circumstances; yet their analyses accord perfectly, and also agree with those of the United States coming from Village Green and Unionville of Pennsylvania, and Buncombe County, North Carolina.*

Localities.	Silica.	Alumina.	Lime.	Magnesia.	Potash & soda.	Water.		
Village Green,	32·31	49·24	10·66	0·30	2·21	5·27	=100	*Craw.*
"	31·06	51·20	9·24	0·28	2·97	5·27	=100	*Craw.*
"	31·26	51·60	10·15	0·50	1·22	4·27	=100	*Craw.*
"	30·18	51·40	10·87	0·92	2·77	4·52	=100·46	*Craw.*
Unionville,...	29·99	50·57	11·31	0·72	2·47	5·14	=100·10	
"	32·15	54·28	11·36	0·05	not estimat'd	0·50	$\ddot{F}e$ *trace,*	*Hartshorne.*
Buncombe Co.,	29·17	48·40	9·87	1·24	6·15	3·99	HF 2·03 =100·80	*Silliman, Jr.*

My analyses were made in the ordinary way, only with more carbonate of soda than is usually employed. The alkalies were separated either by means of hydrofluoric acid or by carbonate of lime, which is preferable to the carbonate of baryta for the decomposition of the silicates.

It is seen that potash and soda are present in small quantities in all the specimens. The composition of this mineral is remarkable for the large proportion of alumina present; but when we look at its origin it is not astonishing to find a silicate of alumina with a small amount of silex.

I regard emerylite as a mineral of elimination from emery, the result of an effort by which the corundum in its formation purifies itself. It is not remarkable that from the mass in which the corundum crystallizes, the silica finding itself in presence with an excess of bases, combines with as large a quantity as its affinity will admit of. In speaking of the formation of emery, I have already alluded to a nodule in my possession that exemplifies this in a very exact manner.

* See Dana's Mineralogy, 3d edition, p. 362.

Notwithstanding the recent discovery of emerylite there is no other species of mica that can be considered so well established as this mineral, or so constant in its composition. Up to the present time this mineral has not been found except with emery or corundum, which frequently contain it in the interior of the mass as well as on the surface. Some emerys contain it in such quantity that it has the aspect of gneiss, as I have already said with reference to certain specimens from Nicaria.

The most beautiful specimens of emerylite come from Naxos; and as the blocks of emery from this island frequently contain it, there will be no difficulty in procuring specimens for cabinets. It is often mixed with diaspore.

Mica. (Muscovite?)—This mica is found on all the emerys which I have examined, but especially on that coming from Kulah. It is always in small plates on the surface of the emery. The analyses of four specimens are as follows:—

Localities.	Silica.	Alumina.	Lime.	Oxyd of iron.	Magnesia.	Pot'h with little soda.	Water.	Manganese.
Gumuch-dagh, ...	42·80	40·61	3·01	1·30	*trace.*	not estimated.	5·62	*trace.*
Kulah, ...	43·62	38·10	0·52	3·50	0·25	7·83	5·51	*trace.*
Kulah, ...	42·71	37·52	1·41	2·82	*trace.*	not estimated.	5·95	*trace.*
Island of Nicaria, .	42·60	37·45	0·68	1·70	*trace.*	9·76	5·20	*trace.*

The composition is very nearly that of the muscovite or Muscovy glass, and until farther examination, I shall retain it under that species, as particular care should be exercised in making new species among the micas.

Chloritoid, (a new variety of this mineral.)—It is found with the emery of Gumuch-dagh in considerable abundance. Its structure is lamellar, cleaving without much difficulty, and the surfaces exposed are always very brilliant. In thin fragments it transmits the light and appears of a dark green color. The powder is greenish grey. Its hardness is 6, and specific gravity 3·52. Heated in the flame of the blowpipe it loses water, and becomes brown from the absorption of oxygen but does not melt. When heated without being in contact with the air it loses its brilliancy, and acquires the aspect of scales from the blacksmith's forge.

This mineral is attacked by the strong acids but is only completely decomposed by sulphuric acid. Melted with four or five times its weight of carbonate of soda it is rendered easily soluble in hydrochloric acid. Great precaution was taken to see that nothing but perfectly pure chloritoid was submitted to analysis, and the possession of well crystallized specimens enabled me to do this without much difficulty.

The method of analysis was to break the mineral in small fragments, to place it in a small platinum crucible, which was introduced into an earthen crucible and surrounded by pulverized quartz: in one word, I pursued the same method as that for estimating the water in emery. For the other ingredients, a new portion was taken, pulverized finely, and attacked either by concentrated sulphuric acid or melted with carbonate of soda, and afterwards dissolved in hydrochloric acid with the addition of a little nitric acid evaporated to dryness, and treated with dilute hydrochloric acid. The liquid separated from the silica is treated with an excess of caustic soda, and the filtered liquid is neutralized by hydrochloric acid and the alumina precipitated by carbonate of ammonia.

The contents of the filter which are essentially peroxyd of iron, are placed in a capsule, dissolved by hydrochloric acid, heated and precipitated by ammonia and thrown on a filter. From the filtered solution the lime and magnesia are separated in the ordinary way. The peroxyd of iron remaining on the filter after being well washed and dried, is weighed and decomposed in a current of hydrogen gas. To the oxyd thus reduced, nitric acid diluted with thirty times its weight of water is added, and digested at 100° to 120° C. for about an hour, stirring frequently, when if the iron has been thoroughly reduced it will be taken up by the acid, and a little alumina left which is weighed and added to the first portion. Ordinarily I never have found more than from one to two per cent. of alumina with the oxyd of iron. Care must be taken to decompose the iron completely, as otherwise the iron will not be entirely taken up by the acid. The mineral thus analyzed afforded as follows:—

	Silica.	Alumina.	Protox. of iron.	Water.	Lime.	Magnesia.	Titanic acid.	Manganese.	Potash & soda
Decomposed by sulphuric acid,	24·10	39·8	27·55	6·5	not estimat'd	not estimat'd	not estimat'd	not estimat'd	0·30
Decomposed by carb. soda, . . .	23·94	39·52	28·05	7·08	0·45	0·80	*trace.*	0·52	——
Decomposed by carb. soda, . . .	23·20	40·21	27·25	6·97	0·83	0·95	*trace.*	not estimat'd	——

These analyses correspond to the following composition.

	Atoms.	At. weight.	Pr. ct.
Silica,	2	1133·40	23·87
Alumina,	3	1925·88	40·57
Protoxyd of iron,	3	1350·00	28·44
Water,	3	337·50	7·12

The most probable formula is

$$\dddot{\overline{A}}l^3\ \dddot{S}i+\dot{F}e^3\ \dddot{S}i+3\dot{\overline{H}}.$$

The minerals which are brought under this species are the chloritspath or chloritoid of the Ural, the Sismondine of St. Marcel and the Masonite of Rhode Island; their analyses and formmulæ are as follows:—

	I.	Oxygen.	II.	Oxygen	III.	Oxygen.	IV.	Oxygen.	V.	Oxygen.	VI.	Oxygen.
Silica, ...	27·48	6	24·40	2	24·1	9	28·27	6	25·18	5	23·91	2
Alumina, . .	35·37	6	45·17	3	44·2	15	32·16	6	33·61	6	39·52	3
Protox. of iron, ...	27·05 }	3	30·29	1	23·8	4	33·72	3	35·31	3	28·05	1
Magnesia, . .	4·29 }											
Water, ...	6·95	3	. . . .	. .	7·6	5	5·00	2	5·88	2	7·08	1

I. Chlorite spar or Chloritoid of the Ural by Bonsdorff. $(\dot{Fe}, \dot{Mg})^3 \dddot{Si} + \ddot{Al}^2 \dddot{Si} + 3\dot{H}$.

II. Chlorite spar of the Ural, Erdmann. $\dot{Fe}^3 \ddot{\overline{Al}} + 2\ddot{\overline{Al}} \dddot{Si}$.

III. Sismondine of St. Marcel, Delesse. $\dot{Fe}^4 \dddot{\overline{Si}}^3 + 5\ddot{\overline{Al}} \dot{\overline{H}}$.

IV. Masonite of Rhode Island, Whitney. $\dot{Fe}^3 \dddot{\overline{Si}} + \ddot{\overline{Al}}^2 \dddot{\overline{Si}} + 2\dot{\overline{H}}$.

V. Chlorite spar according to Rammelsberg requires, $3\dot{R}^3 \dddot{Si} + 2\ddot{Al}^3 \dddot{Si} + 6\dot{H}$.

VI. Chloritoid of Asia Minor, J. L. Smith. $\ddot{\overline{Al}}^3 \dddot{\overline{Si}} + \dot{Fe}^3 \dddot{\overline{Si}} + 3\dot{\overline{H}}$.

This mineral is found very abundantly with the emery of Gumuch-dagh; it covers the surface of the blocks, and sometimes enters largely into the substance of the emery. It is easy to see from the composition of this mineral, that it is formed by elimination from the mass of emery at the time of its consolidation, which by this means tends to purify itself. The nodule of which I have already spoken under the head of emery and of emerylite goes to sustain this view of the question.

On the emery of the other localities, I have not found this chloritoid. Its composition is not in perfect accordance with the known varieties of chloritoid, and differs from Sismondine (which it approaches most in composition) by its imperfect solubility in hydrochloric acid.

Black Tourmaline.—This mineral is found abundantly with the emery of Naxos, and also in small quantities with that of other localities. It appears to have replaced the chloritoid that is found so abundantly with the emery of Gumuch-dagh.

The crystals are found agglomerated on the surface, and also disseminated in the interior of the emery. This mineral like the last is strongly basic, containing a little more than thirty per cent. of silica.

Chlorite.—With the emery of Gumuch-dagh we find a chlorite. It is in compact masses composed of an agglomeration of small crystalline plates, and contains octahedral crystals of magnetic oxyd of iron. Analysis gives as its composition,

Silica,	27·20
Alumina,	18·62
Protoxyd of iron,	23·21
Magnesia,	17·64
Water,	10·61

It is identical with the chlorite of *Mont des sept-Lacs* which gave M. Marignac,

Silica,	27·14
Alumina,	19·19
Protoxyd of iron,	24·76
Magnesia,	16·78
Water,	11·50

It is the same as the chlorite of *St. Christophe* and the ripidolite of *Rauris* and of *St. Gothard.* The formula given by von Kobell is,

$$2\dot{M}g\,\ddot{\bar{A}}l+3(\dot{M}g\,\dot{F}e)^2\,\dddot{S}i+6\dot{H}.$$

Magnetic Oxyd of Iron.—This is found with the emery of every locality. It enters into the composition of the emery itself and is also found on the surface in regular octahedral crystals. We find it frequently massive and of strong polarity. That of Gumuch-dagh contains a trace of titanic acid.

Oligiste Iron.—It is associated with all the emerys, and sometimes enters into their composition. It is also found in detached masses, either amorphous or as crystallized specular iron.

Hydrated Oxyd of Iron.—This oxyd of iron is not unfrequently found with emery, covering the surface. It is found with pyrites having resulted from the decomposition of this mineral.

Iron Pyrites.—Pyrites is found principally with the emery of Gumuch and Nicaria. At the latter locality it is in small crystals in the interior of the mass. At Gumuch it is principally on the surface but much less abundant than at Nicaria.

Rutile.—This oxyd of titanium is found with the emery of Gumuch-dagh and of Kulah, where I obtained some large detached crystals. I have also a specimen, with it in small crystals on diaspore attached to emery from Gumuch-dagh.

Ilmenite.—It has been found on the gangue of the emery of Kulah in minute crystals, of the usual form of this mineral.

Titaniferous iron.—Titaniferous iron is found with almost all the varieties of emery that I have examined, but I have analyzed none but that associated with the emery of Nicaria. Care being first taken to see that it was anhydrous, one gramme of it was calcined in a current of oxygen and it augmented ·019, which indicated the presence of ·171 gramme of protoxyd of iron, and corresponds to ·190 gramme of peroxyd of iron: the same portion then decomposed by a current of hydrogen gas and the loss sustained was equal to ·222 gramme of oxygen, which corresponds to ·740 gramme of peroxyd of iron; deducting from this the quantity of peroxyd equal to the protoxyd (·171) contained in the mineral, we have ·550 gramme for the quantity of peroxyd present. The mass reduced by hydrogen was treated with hydrochloric acid, and the part not dissolved (·230 gramme) was titanic acid with a little alumina. The acid solution contained ·010 lime, and a trace of alumina. The titanic acid was examined as to its purity and was found to contain no silica, and only a trace of alumina. The result of the analysis is,

Protoxyd of iron,	17·10
Peroxyd of iron,	55·00
Titanic acid,	23·01
Lime,	1·00
Alumina,	a little, not estimated.

This titaniferous iron corresponds in composition to the Washingtonite of Prof. Shepard as analyzed by M. Marignac, and to the titaniferous iron of Arendal analyzed by M. Mosander. Its sp. grav. is 4·78.

There are still two or three minerals that I have found associated with emery, but their specific characters have not been well established, on account of the difficulty of obtaining enough in a state of sufficient purity for analysis.

The study of these accidental minerals in contact with emery has led to several general conclusions which have been mentioned under the description of the different species; and now I do not risk much in saying, that the hydrates of alumina, as diaspore,—as well as the silicates, as emerylite, chloritoid and tourmaline,—and the minerals of iron, as magnetic, titaniferous iron, &c,—will be found almost everywhere with the emery and corundum.

My labors on this subject are thus terminated, and it is to be hoped that the examination of the emery of Asia Minor has served to elucidate the geology and mineralogy of this substance, until now but little known except in its uses.